



Biological Assessment Report

**Crooked Creek, Huzzah Creek, and East Fork Huzzah Creek,
Crawford and Dent Counties, Missouri**

Fall 2016 – Spring 2017

Prepared for:
Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program
Water Pollution Control Branch

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1.0 Introduction

At the request of the Missouri Department of Natural Resources (**MoDNR**) Water Protection Program (**WPP**), the Environmental Services Program (**ESP**) Water Quality Monitoring Section (**WQMS**) conducted a macroinvertebrate biological assessment and habitat study of Crooked Creek, Huzzah Creek, and East Fork Huzzah Creek during the fall of 2016 and spring of 2017. Fall sampling was conducted on September 20-21, 2016, and consisted of macroinvertebrate sampling, stream habitat assessments, water quality sampling, and sediment sampling. During the spring, sampling was conducted on March 14, 2017, and consisted of macroinvertebrate sampling and water quality sampling at the same study stations. Sampling was conducted by Brandy Bergthold, Brian Nodine, Raissa Espejo, and Dave Gullic.

Crooked Creek, water body identification (**WBID**) 1928, and Huzzah Creek, WBID 1903, are both classified as class P streams in the Missouri Water Quality Standards (**WQS**) (MoDNR 2014). Crooked and Huzzah creeks have the following designated uses based on the 2014 WQS: irrigation, livestock and wildlife watering; protection of warm water aquatic life and human health-fish consumption; cool water fisheries habitat; category A whole body contact recreation; and secondary contact recreation. East Fork Huzzah Creek is classified as a class P stream from Section 1, T. 34 N., R. 3 W. to Section 20, T. 34 W., R. 2 W. (WBID 1925) and a class C stream from Section 20, T. 34 W., R. 2 W. to Section 29, T. 34 N., R. 2 W. (WBID 1926). East Fork Huzzah Creek station 1 is located within the class P section and East Fork Huzzah Creek station 2 is located within the class C section. Both sections of East Fork Huzzah Creek have the following designated uses based on the 2014 WQS: irrigation, livestock and wildlife watering; protection of warm water aquatic life habitat and human health-fish consumption; category B whole body contact recreation; and secondary contact recreation. A class P stream is defined as a stream that maintains permanent flow even in drought periods. Class C streams may cease flow during dry periods but maintain permanent pools. Category A whole body contact applies to waters designated as public swimming and recreational use areas. Category B whole body contact applies to waters that are not designated for public swimming areas and public recreational uses.

Crooked Creek is listed on Missouri's 303(d) List of Impaired Waters for exceedances of water quality criteria for the protection of aquatic life (MoDNR 2015b). The pollutants of concern are cadmium, lead, and copper from the Buick smelter. Missouri does not currently have numeric water quality criteria for the protection of aquatic life from metals toxicity in stream sediment. Probable Effect Concentrations (**PECs**) suggested by MacDonald et al. (2000) are used for assessing compliance of metals toxicity with narrative general criteria. PECs are the concentration at which toxic effects to aquatic life are likely to occur. East Fork Huzzah Creek and Huzzah Creek are not on the 303(d) List of Impaired Waters. Bioassessments have been conducted on East Fork Huzzah Creek in the past and have rendered inconclusive results as to the stream's ability to maintain a fully supporting biological community. A 2008-2009 biological assessment of Crooked Creek concluded that dissolved metals continue to affect the stream (Irwin 2009). Huzzah

Creek was sampled within 3 miles downstream of the confluence with Crooked Creek to assess the downstream effects of the mining activity in the Crooked Creek watershed.

2.0 Sampling Locations and Study Area

Crooked Creek, Huzzah Creek, and East Fork Huzzah Creek are located within the Ozark/Meramec Ecological Drainage Unit (**EDU**, Figure 1). An EDU is a region in which biological communities and habitat conditions can be expected to be similar.

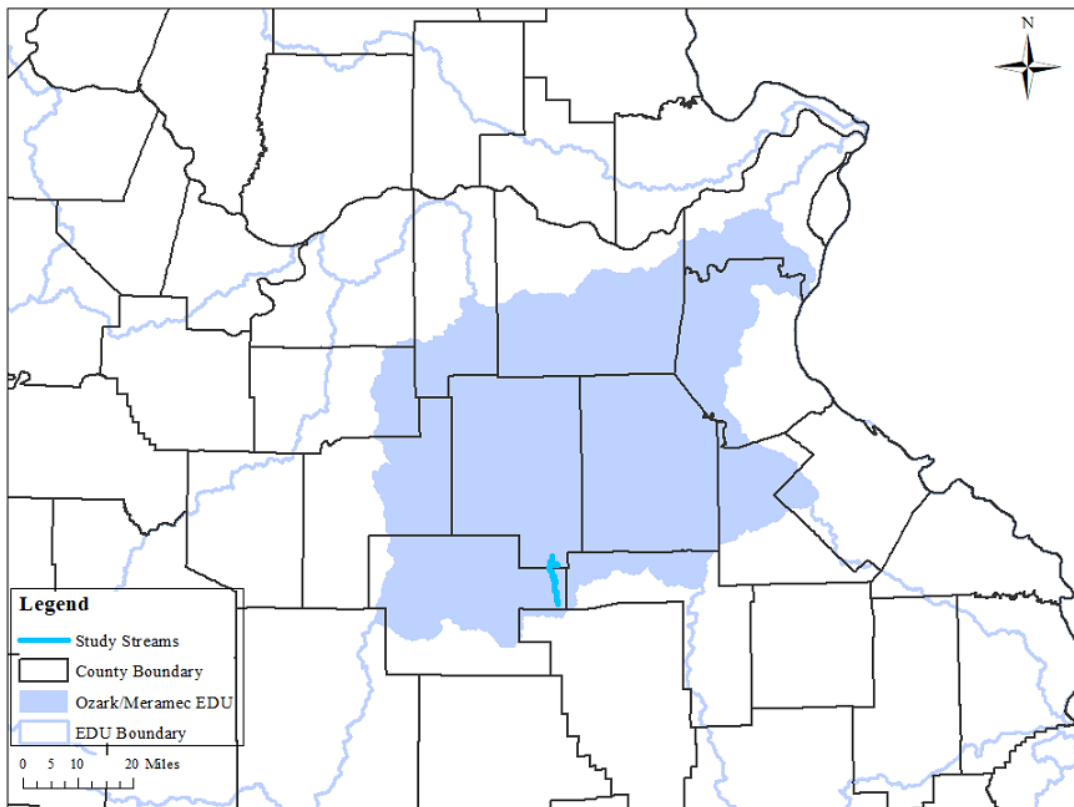


Figure 1. Location of Study Streams within the Ozark/Meramec EDU

Four stations were sampled. Station locations and descriptions are listed below and shown in Figure 2. All sampling stations were located in Universal Transverse Mercator (**UTM**) Zone 15.

Sampling Locations

Crooked Creek 0.9 (NW 1/4 S. 31, T. 35 N., R. 02 W.) was sampled downstream of Willhite Road in Crawford County. UTM coordinates collected at the upstream boundary of the sample reach are UTMN 4175376, UTME 658923.

Huzzah Creek 4 (NE 1/4 SE 1/4 S. 25, T. 35 N., R. 03 W.) was sampled downstream of the mill at Dillard Mill State Historic Site in Crawford County. The UTM coordinates at the downstream boundary of the sampling reach are UTMN 4176261, UTME 658487.

East Fork Huzzah Creek 1 (SE 1/4 S. 06, T. 34 N., R. 02 W.) was sampled just west of County Road 4430 in Dent County. The UTM coordinates at the downstream boundary of the sampling reach are UTMN 4170336, UTME 659218.

East Fork Huzzah Creek 2 (SL 20/29, T. 34 N., R. 02 W.) was sampled downstream of County Road 5300 in Dent County. The UTM coordinates at the upstream boundary of the sampling reach are UTMN 4164948, UTME 659968.

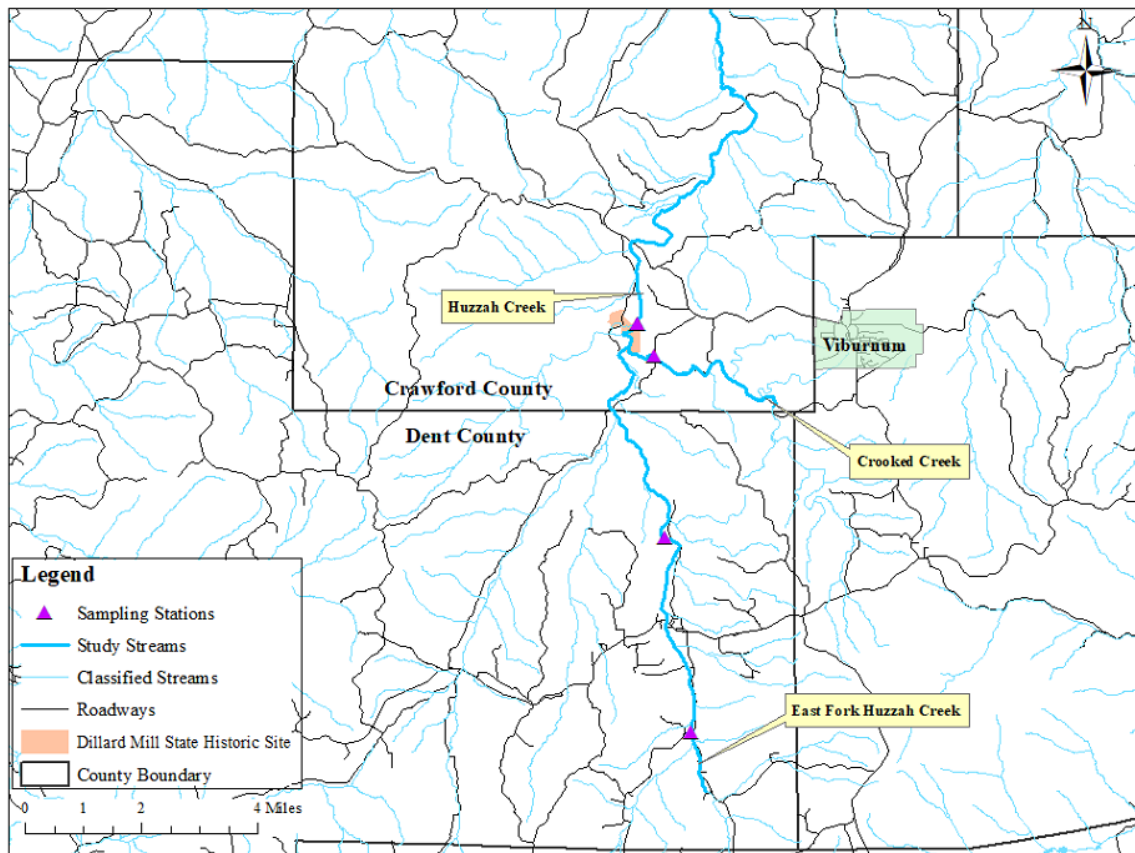


Figure 2. Crooked Creek, Huzzah Creek, and East Fork Huzzah Creek Sampling Locations

Table 1 compares the land cover percentages from the Ozark/Meramec EDU and the 12-digit Hydrologic Unit Code (HUC) containing the study stations. Percent land use data were derived from Thematic Mapper satellite images from 2000-2004 and interpreted by the Missouri Resource Assessment Partnership (Sowa et al. 2004).

Table 1. Percent Land Use in Study Stations and the Ozark/Meramec EDU

	12-digit HUC	Urban/Im- pervious	Crop- land	Grass- land	Forest- land	Herba- ceous	Wetland/ Open water
Crooked Creek	071401020402	1.8	0.3	11.0	81.1	5.3	0.4
Huzzah Creek 4	071401020402	1.8	0.3	11.0	81.1	5.3	0.4
E Fk Huzzah Creek	071401020401	0.5	0.1	18.3	75.3	5.3	0.4
Ozark/Meramec EDU	--	4.0	1.9	27.8	57.2	5.6	2.3

Comparison of land use between the 12-digit HUC containing the study segments and the Ozark/Meramec EDU showed the study streams' watersheds contained less urban/impervious cover, less cropland, and less grassland than the EDU. The study streams contained more forested land than the EDU.

3.0 Objectives

The primary objective of this study was to determine if Crooked Creek, Huzzah Creek, and East Fork Huzzah Creek support the beneficial use designation of warm water aquatic life habitat protection based on biological criteria calculated from reference stream macroinvertebrate data in the Ozark/Meramec EDU.

The macroinvertebrate community and instream habitat were compared with biological criteria reference (**BIOREF**) stream data from the Ozark/Meramec EDU. Water quality was compared with Missouri's WQS (MoDNR 2014) and U. S. EPA's ambient water quality criteria recommendations for nutrients (USEPA 2000). Sediment toxicity was compared with MacDonald's recommended PECs for metals toxicity (MacDonald et al. 2000).

3.1 Null Hypotheses

- 1) Stream habitat assessment scores of Crooked Creek, Huzzah Creek, and East Fork Huzzah Creek will be similar to those of Huzzah Creek, the BIORREF station located in the Ozark/Meramec EDU.
- 2) The macroinvertebrate communities in Crooked Creek, Huzzah Creek, and East Fork Huzzah Creek will be similar to the macroinvertebrate communities of BIORREF streams in the Ozark/Meramec EDU.
- 3) Physicochemical water quality of Crooked Creek, Huzzah Creek and East Fork Huzzah Creek will meet the WQS.
- 4) Metals toxicity values of the sediment samples will meet MacDonald's recommended PEC values (MacDonald et al. 2000) times 150 percent.

4.0 Methods

4.1 Stream Habitat Assessment Project Procedure

Standardized assessment procedures were followed as described for riffle/pool prevalent streams in the Stream Habitat Assessment Project Procedure (**SHAPP**, MoDNR 2016k). According to the SHAPP, an aquatic community is influenced by the quality of the stream habitat. Stream habitat quality is scored for each station, and the scores are compared with a control stream (BIOREF reach) SHAPP score. If the SHAPP score at a study station is $\geq 75\%$ of the SHAPP control score, the stream habitat at the study station is considered to be comparable to the control stream. Huzzah Creek was chosen as the SHAPP control. The site is a BIOREF station located at the United States Forest Service Red Bluffs Recreation Area near Davisville, Missouri, in Crawford County (approximately 10 miles downstream of the Huzzah Creek study station). The habitat assessment of the BIOREF stream was conducted on September 22, 2016. SHAPP scores were calculated for the study stations, compared to the Huzzah Creek BIOREF station, and examined for irregular results.

4.2 Macroinvertebrate Sampling and Analyses

Macroinvertebrate sampling was conducted according to the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (**SMSBPP**, MoDNR 2012). Crooked Creek, Huzzah Creek, and East Fork Huzzah Creek are considered riffle/pool dominated systems. The three standard habitats sampled at all locations were flowing water over coarse substrate, non-flowing water over depositional substrate, and submerged rootmat. Macroinvertebrate samples were subsampled in the laboratory and identified to specific taxonomic levels (MoDNR 2016h) to develop biological metric values (MoDNR 2012).

Reference streams within the EDU represent the best available conditions and are the basis for calculating Macroinvertebrate Stream Condition Index (**MSCI**) scores. Crooked Creek, Huzzah Creek, and East Fork Huzzah Creek macroinvertebrate data were evaluated relative to BIOREF streams in the Ozark/Meramec EDU. Biological criteria are calculated separately for the fall (mid-September through mid-October) and spring (mid-March through mid-April) index periods. The SMSBPP provides details on the calculation of metrics and scoring of the multi-metric MSCI. The four components of the MSCI are Taxa Richness (**TR**); Ephemeroptera, Plecoptera, and Trichoptera Taxa (**EPTT**); Biotic Index (**BI**); and the Shannon Diversity Index (**SDI**). An MSCI score of 16-20 is considered fully supporting, 10-14 partially supporting, and 4-8 non-supporting of the protection of warm water aquatic life beneficial use designation as listed in the WQS (MoDNR 2014).

Poulton et al. (2010) incorporated additional metrics to analyze metals pollution in mining streams of the Viburnum Trend in Missouri: percent dominant taxon, the ratio of tolerant to intolerant Ephemeroptera, percent scrapers, and percent Chironomidae. Intolerant Ephemeroptera were defined as those with a BI value less than five. These

additional metrics have been incorporated into the analyses of the macroinvertebrate community.

4.3 Physicochemical Water Sampling and Sediment Analyses

Physicochemical water samples were handled according to the appropriate MoDNR ESP Standard Operating Procedures or Project Procedures. Results for physicochemical water parameters were examined by season and station by *in situ* field measurements or grab samples collected in accordance with the SOP MDNR-ESP-001, *Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations* (MoDNR 2016a). All samples were kept on ice during transport to ESP.

Water quality parameters were measured *in situ* or collected and returned for analyses at the ESP laboratory in Jefferson City. Turbidity (NTU, MoDNR 2016c) was measured in the ESP, WQMS biology laboratory. Discharge (cubic feet per second-cfs, MoDNR 2015a), DO (mg/L, MoDNR 2016g), specific conductance ($\mu\text{S}/\text{cm}$, MoDNR 2016f), pH (MoDNR 2016d), and temperature ($^{\circ}\text{C}$, MoDNR 2016e), were measured in the field. The ESP Chemical Analysis Section conducted analyses for the following: nitrate+nitrite-nitrogen, total nitrogen, total phosphorus, ammonia as N, sulfate, chloride, TSS/non-filterable residue, dissolved calcium, and dissolved magnesium (all parameters reported in mg/L). The ESP Chemical Analysis Section also conducted analyses for dissolved metals (barium, cadmium, lead, nickel, zinc), reported in $\mu\text{g}/\text{L}$.

Sediment was collected in accordance with SOP MDNR-ESP-011, *General Sampling Considerations for Chemical Analysis of Sediment* (2016b). Total metals analysis (arsenic, cadmium, copper, lead, nickel, and zinc) was conducted by the ESP Chemical Analysis Section and reported in $\mu\text{g}/\text{kg}$.

4.4 Discharge

Stream discharge was measured using a SonTek/YSI FlowTracker Handheld Acoustic Doppler Velocimeter at all stations during both sampling seasons in accordance with the SOP MDNR-ESP-113, *Flow Measurements in Open Channels* (MoDNR 2015a).

4.5 Quality Assurance/Quality Control (QA/QC)

4.5.1 Field Meters

All field meters used to collect water quality parameters were maintained in accordance with *Quality Control Procedures for Checking Water Quality Field Instruments* (MoDNR 2016i).

4.5.2 Biological Samples

Steps to assure accuracy of organism removal from sample debris were performed consistent with those methods found in the SMSBPP document (MoDNR 2012).

4.5.3 Biological Data Entry

All macroinvertebrate data were entered into the WQMS macroinvertebrate database consistent with *Quality Control Procedures for Data Processing* (MoDNR 2016j).

4.5.4 Duplicate Sample Collection

Duplicate samples are collected at two randomly selected sampling stations per season for macroinvertebrates and for 10 percent of water samples. Duplicate samples are obtained from the same location at essentially the same time as the true sample following procedures described in *Quality Assurance/Quality Control for Environmental Data Collection* (MoDNR 2013). The true samples and the duplicate samples are analyzed for the same set of parameters and reported independently. A duplicate is used to assess the precision associated with sampling methodology, sample heterogeneity, and analytical procedures (MoDNR 2013). Duplicate macroinvertebrate samples are analyzed for Quantitative Similarity Index for Taxa (**QSIT**), which compares the two samples in terms of presence or absence of taxa and taking relative abundance (percent composition) of each taxon into account (MoDNR 2012). Duplicate macroinvertebrate samples are expected to have a 70 percent or greater taxa similarity (Rabeni et al. 1999; MoDNR 2012). A duplicate sample was collected for both physicochemical and macroinvertebrate parameters from the Huzzah Creek 4 during the fall sampling period.

5.0 Results

5.1 Stream Habitat Assessment

Habitat assessment scoring results are found in Table 2. If the study station SHAPP score is $\geq 75\%$ of the control station score, the stations are considered to contain comparable habitats to the control station. All stations scored $\geq 75\%$ of the SHAPP control station at the Huzzah Creek BIOREF station. Based on SHAPP scores, it is inferred that the study stations have habitats similar to the BIOREF stream and should, therefore, support a comparable biological community.

Table 2. Habitat Categories and Scores from Stream Habitat Assessments
 for Crooked Creek, Huzzah Creek, East Fork Huzzah Creek, and the BIOREF

Stream Habitat Parameters	Crooked Cr 0.9	Huzzah Cr 4	E Fk Huzzah 1	E Fk Huzzah 2	Huzzah Cr (BIOREF)
Habitat Assessment Date	9/20/16	9/20/16	9/20/16	9/21/16	9/22/16
Epifaunal Substrate	I(16)	I(16)	I(18)	I(16)	I(17)
Embeddedness	II(15)	I(16)	II(14)	II(13)	I(18)
Velocity/Depth Regime	II(14)	I(18)	I(18)	III(10)	I(20)
Sediment Deposition	II(11)	II(12)	II(15)	II(13)	II(12)
Channel Flow Status	III(6)	II(11)	II(13)	III(8)	II(14)
Channel Alteration	I(19)	I(18)	I(16)	I(19)	I(17)
Riffle Quality	II(12)	II(14)	I(17)	I(17)	I(19)
Left Bank Stability	I(10)	I(10)	II(7)	I(9)	II(6)
Right Bank Stability	II(6)	I(10)	I(10)	I(9)	I(10)
Left Bank Vegetative Protection	IV(0)	IV(2)	IV(1)	IV(2)	IV(1)
Right Bank Vegetative Protection	IV(0)	IV(2)	II(6)	IV(1)	IV(1)
Left Bank Riparian Zone Width	II(8)	I(10)	III(5)	I(9)	I(9)
Right Bank Riparian Zone Width	III(5)	I(10)	II(6)	I(10)	I(10)
Total Habitat Score	122	149	146	136	154
Percentage of BIOREF	79	97	95	88	--

Habitat parameter categories range from I to IV with category I = optimal, category II = suboptimal, category III = marginal, and category IV = poor. Habitat parameter scores are listed in parentheses and range from 0 to 20 except for vegetative protection and riparian zone categories, which range from 0 to 10.

All study stations had optimal epifaunal substrate with cobble, large gravel, and submerged debris instream. Embeddedness was suboptimal at Crooked Creek and the East Fork Huzzah Creek stations and optimal at Huzzah Creek 4. Sediment deposition was suboptimal at all stations. Optimal velocity/depth regimes were present at Huzzah Creek 4 and East Fork Huzzah Creek 1. Crooked Creek and East Fork Huzzah Creek 2 had few areas considered deep depth regimes. Crooked Creek and Huzzah Creek 4 had suboptimal riffle quality with riffle length less than two times the riffle width. Both stations on East Fork Huzzah Creek had optimal riffle quality. Channel flow status was suboptimal to marginal at all stations, filling approximately 75 percent of the channel at Huzzah Creek 4 and East Fork Huzzah Creek 1 but only filling approximately 25 percent of the channel at Crooked Creek and East Fork Huzzah Creek 2. Channel alterations were minimal. The channel at Crooked Creek had been reinforced for a short distance due to past stream bank erosion adjacent to the county road. Little active erosion was visible at the study stations, and stream banks were considered stable to moderately stable at all stations. Although vegetative protection along the banks was low, the stations mostly had well-established riparian corridors with a mix of trees and understory growth. Crooked

Creek and East Fork Huzzah Creek 1 both had pasture areas along the stream that affected the riparian corridor.

Huzzah Creek at Red Bluffs Recreational Area, the SHAPP control, contained optimal epifaunal substrate. The substrate consisted of mostly gravel and cobble with instream woody debris and leaf litter. There was little sediment deposition evident, and optimal velocity/depth regimes were present. Channel flow status ranked comparable to the study station on Huzzah Creek 4 and East Fork Huzzah Creek 1 filling approximately 75% of the channel. The stream was adjacent to a campground and had an area of rip rap along the bank to prevent the stream from encroaching on the campground. Although vegetative protection along the banks was minimal, the stream banks had little active erosion. The riparian area along Huzzah Creek was optimal.

5.2 Biological Assessment and Macroinvertebrate Community Analyses

Tables 3 and 4 provide scoring criteria and results for the fall and spring index periods. MSCI scores were calculated by scoring study station biological metrics using Ozark/Meramec EDU biological criteria. An MSCI score of 16-20 is considered fully supporting, 10-14 is partially supporting, and 4-8 is considered non-supporting of the beneficial use designation. All four study stations had fully supporting MSCI scores during the fall sampling season. During the spring, only Huzzah Creek 4 and East Fork Huzzah Creek 1 had fully supporting MSCI scores. Crooked Creek and East Fork Huzzah Creek 2 scored in the partially supporting biological criteria MSCI category in spring.

Table 3. Fall 2016 Metric Values and Scores for Crooked Creek, Huzzah Creek, and East Fork Huzzah Creek, Using Ozark/Meramec Biological Criteria

Stations	TR	EPTT	BI	SDI	MSCI	Support
Crooked Cr 0.9	82	25	5.6	3.40		
Score	5	5	3	5	18	Full
Huzzah Cr 4a	87	32	5.7	3.01		
Score	5	5	3	3	16	Full
Huzzah Cr 4b	84	30	5.7	3.09		
Score	5	5	3	3	16	Full
E Fk Huzzah 1	88	31	5.7	3.20		
Score	5	5	3	5	18	Full
E Fk Huzzah 2	87	25	5.3	3.58		
Score	5	5	5	5	20	Full
BIOREF Score=5	>80	>23	<5.6	>3.13	20-16	Full
BIOREF Score=3	80-40	23-11	5.6-7.8	3.13-1.57	14-10	Partial
BIOREF Score=1	≤40	≤11	≥7.8	≤1.57	8-4	Non

MSCI Scoring Table (in light gray) developed from Ozark/Meramec BOREF streams ($n = 10$).
 TR=Taxa Richness; EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index;
 SDI=Shannon Diversity Index.

Table 4. Spring 2017 Metric Values and Scores for Crooked Creek, Huzzah Creek, and East Fork Huzzah Creek Using Ozark/Meramec Biological Criteria

Stations	TR	EPTT	BI	SDI	MSCI	Support
Crooked Cr 0.9	84	28	5.6	2.75		
Score	3	3	5	3	14	Partial
Huzzah Cr 4	92	35	5.5	3.57		
Score	3	5	5	5	18	Full
E Fk Huzzah 1	91	35	5.0	3.51		
Score	3	5	5	5	18	Full
E Fk Huzzah 2	84	23	5.3	3.28		
Score	3	3	5	3	14	Partial
BIOREF Score=5	>93	>31	<5.9	>3.33	20-16	Full
BIOREF Score=3	93-47	31-15	5.9-7.9	3.33-1.67	14-10	Partial
BIOREF Score=1	≤47	≤15	≥7.9	≤1.67	8-4	Non

MSCI Scoring Table (in light gray) developed from Ozark/Meramec BOREF streams ($n = 8$).
 TR=Taxa Richness; EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index;
 SDI=Shannon Diversity Index.

Fall 2016

The fall 2016 macroinvertebrate community analysis is shown in Table 5. The total percentage of EPT taxa at the study stations ranged from 32.4 percent to 53.6 percent (compared to the BIOREF average of 54.7 percent). Coleoptera taxa ranged from 16.3 percent to 38.1 percent at the study stations, compared to 15.9 percent of the BIOREF samples. The coleopteran family Elmidae was the most common family collected at Huzzah Creek 4 and East Fork Huzzah Creek 1. Dipteran taxa ranged from 10.3 percent to 26.3 percent compared to the BIOREF average of 12. The dipteran family Chironomidae was prevalent at Crooked Creek, Huzzah Creek 4, and East Fork Huzzah Creek 2.

The elmid *Stenelmis* was common at all four study stations. *Optioservus sandersoni* (another Elmidae) was also common at all sampling stations but with lower abundance than *Stenelmis*. The chironomid taxa *Tanytarsus* and *Rheotanytarsus* were common (within the top three taxa) at Huzzah Creek 4, and *Cricotopus/Orthocladius* grp. was more commonly collected at the remaining stations. The caddisfly *Cheumatopsyche* (Hydropsychidae) was common at Crooked Creek and East Fork Huzzah Creek 2 but collected in lesser abundance at Huzzah Creek 4 and East Fork Huzzah Creek 1. *Hyalella azteca* (Hyalellidae) was the second most common taxon (*Stenelmis* was the most common) at East Fork Huzzah Creek 1 but made up less than two percent of the macroinvertebrate community at the remaining stations.

Table 5. Fall 2016 Macroinvertebrate Community Analysis

Stations	BIOREF	Crooked	Huzzah	Huzzah	E Fk Huzzah	E Fk Huzzah
Variables	Average	Cr 0.9	Cr 4a	Cr 4b	Cr 1	Cr 2
% Ephemeroptera	49.6	35.3	26.0	25.5	29.9	32.2
% Plecoptera	0.2	0.2	2.0	2.0	0.2	0.3
% Trichoptera	4.9	18.1	5.5	4.9	5.3	14.1
% Total EPT	54.7	53.6	33.5	32.4	35.4	46.6
% Coleoptera	15.9	16.3	37.4	38.1	30.2	17.5
% Diptera	12.0	21.0	26.3	25.8	10.3	19.4
% Dominant Macroinvertebrate Families						
Chironomidae	11.2	17.9	25.1	25.0	9.8	16.7
Hydropsychidae	1.3	14.2	2.5	3.4	3.0	11.7
Baetidae	1.7	11.3	9.1	4.0	10.9	6.3
Elmidae	14.1	10.3	35.4	34.4	25.9	14.0
Caenidae	12.0	9.7	9.5	11.1	4.8	8.4
Heptageniidae	14.2	8.8	4.2	7.1	8.6	8.9
Psephenidae	1.4	5.5	1.4	3.4	4.1	3.5
Hyalellidae	2.9	1.3	0.3	1.1	18.0	1.9

The top two families of the study stations are shown in bold.

During the fall, taxa with BI values ≥ 5.0 (more tolerant) ranged from 62 percent to 85 percent of the samples from the study streams (Figure 3). In comparison, BIOREF

streams contained 68 percent of taxa within the same category. East Fork Huzzah Creek 2 had the lowest percent of taxa within the combined BI categories of more tolerant taxa and Huzzah Creek 4 had the highest percent. Taxa with BI values <5.0 (more sensitive) ranged from 14 percent to 35 percent, compared to BIOREF streams in which the lower BI category composed an average of 30 percent of samples.

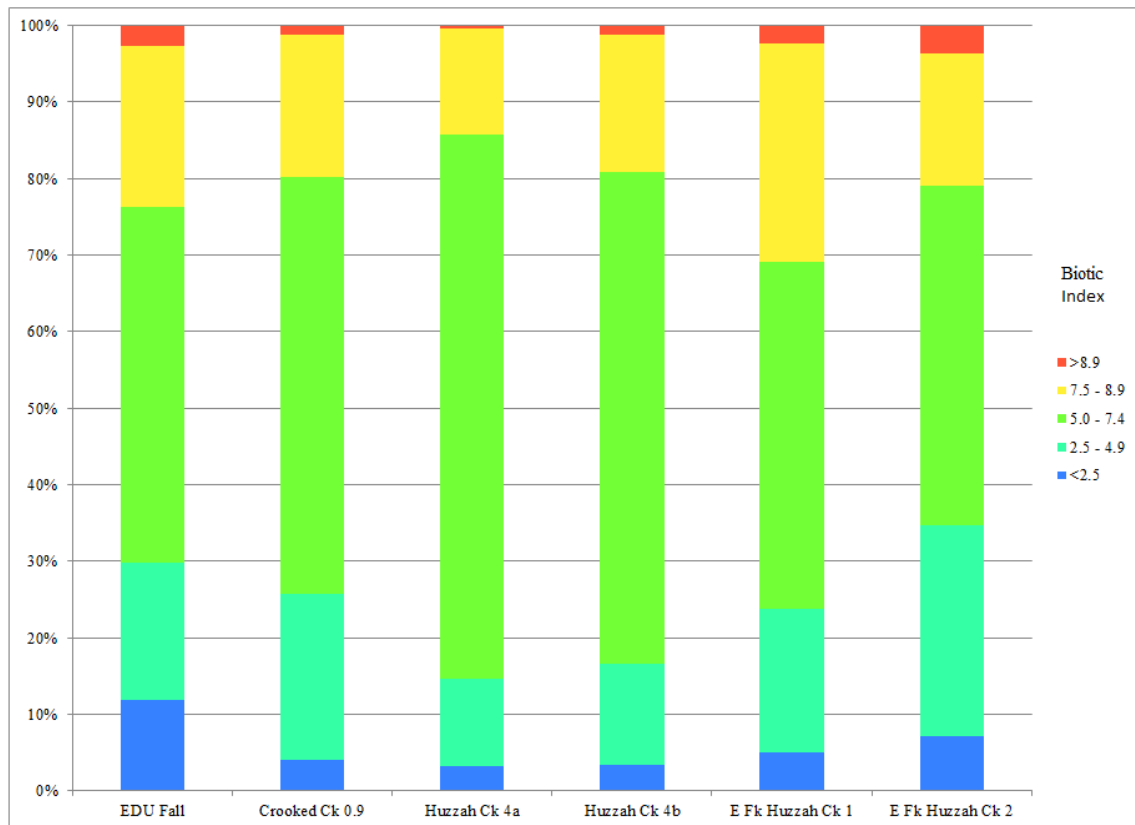


Figure 3. Fall 2016 Percent Taxa by Biotic Index Range

Spring 2017

The spring 2017 macroinvertebrate community analysis is shown in Table 6. The total percentage of EPT taxa at the study stations ranged from 23.3 percent to 39.7 percent (compared to the BIOREF average of 41.4 percent). The order Coleoptera was collected in lesser abundance than in the fall. Coleoptera taxa ranged from 3.4 percent to 6.7 percent at the study stations and 9.9 percent at the BIOREF samples. The coleopteran family Elmidae was again the most common beetle family collected. Dipteran taxa ranged from 47.2 percent to 70.3 percent, compared to the BIOREF average of 37.9. The dipteran family Chironomidae was the most prevalent dipteran at all study stations, ranging from 44.6 to 66.5 percent of the macroinvertebrate community.

The elmid *Optioservus sandersoni* was more commonly collected than *Stenelmis* during the spring, but neither made up more than 6.2 percent of the macroinvertebrate

community. The chironomid *Cricotopus/Orthocladius* grp. was the most common taxon collected at all stations, ranging from 15.6 percent of the East Fork Huzzah Creek 1 sample to 43.4 percent of the Crooked Creek 0.9 sample. Other individual chironomid taxa (*Rheotanytarsus*, *Dirotendipes*, *Tanytarsus*, *Thienemannimyia* grp, and *Cricotopus bicinctus*) made up less than 10 percent of the samples, but collectively this family makes up the majority of all the samples. Leuctridae, the rolled-winged stonefly, was the second most common family collected at Crooked Creek. As in the fall, *Cheumatopsyche* (Hydropsychidae) was the most common Trichoptera taxon collected at all stations and the second most common taxon Huzzah Creek 4. Baetidae was the second most common family at East Fork Huzzah Creek 1, comprising mostly *Acentrella* and *Acerpenna*. Heptageniidae was the second most common family collected at East Fork Huzzah Creek 2 and comprised mostly *Maccaffertium pulchellum* and *M. bednariki*.

Table 6. Spring 2017 Macroinvertebrate Community Analysis

Stations	BIOREF	Crooked	Huzzah	E Fk Huzzah	E Fk Huzzah
Variables	Average	Cr 0.9	Cr 4	Cr 1	Cr 2
% Ephemeroptera	34.6	9.5	17.0	25.7	15.6
% Plecoptera	1.9	8.7	4.7	4.1	4.6
% Trichoptera	4.9	6.7	12.2	9.9	3.1
% Total EPT	41.4	24.9	33.9	39.7	23.3
% Coleoptera	9.9	3.4	6.7	6.7	4.3
% Diptera	37.9	65.6	54.9	47.2	70.3
% Dominant Macroinvertebrate Families					
Chironomidae	34.7	62.5	52.8	44.6	66.5
Leuctridae	0.1	6.0	0.2	1.6	3.6
Hydropsychidae	2.2	4.5	10.0	6.9	2.9
Heptageniidae	7.8	4.5	9.1	6.7	6.8
Acarina	3.7	3.2	2.0	1.9	1.5
Elmidae	9.4	2.8	6.2	6.2	4.1
Baetidae	0.3	2.1	1.2	10.7	4.9
Ephemerellidae	6.3	<0.1	3.3	6.3	1.9

The top two families of the study stations are shown in bold.

During the spring, taxa with BI values ≥ 5.0 (more tolerant) ranged from 57 percent to 77 percent of the samples from the study streams (Figure 4). In comparison, BIORREF streams contained 75 percent of taxa within the same categories. East Fork Huzzah Creek 1 had the lowest percent of taxa within the combined BI categories of more tolerant taxa and Crooked Creek had the highest percent. Taxa with BI values < 5.0 (more sensitive) ranged from 23 percent to 43 percent, compared to BIORREF streams, in which the lower BI category composed an average of 25 percent of samples.

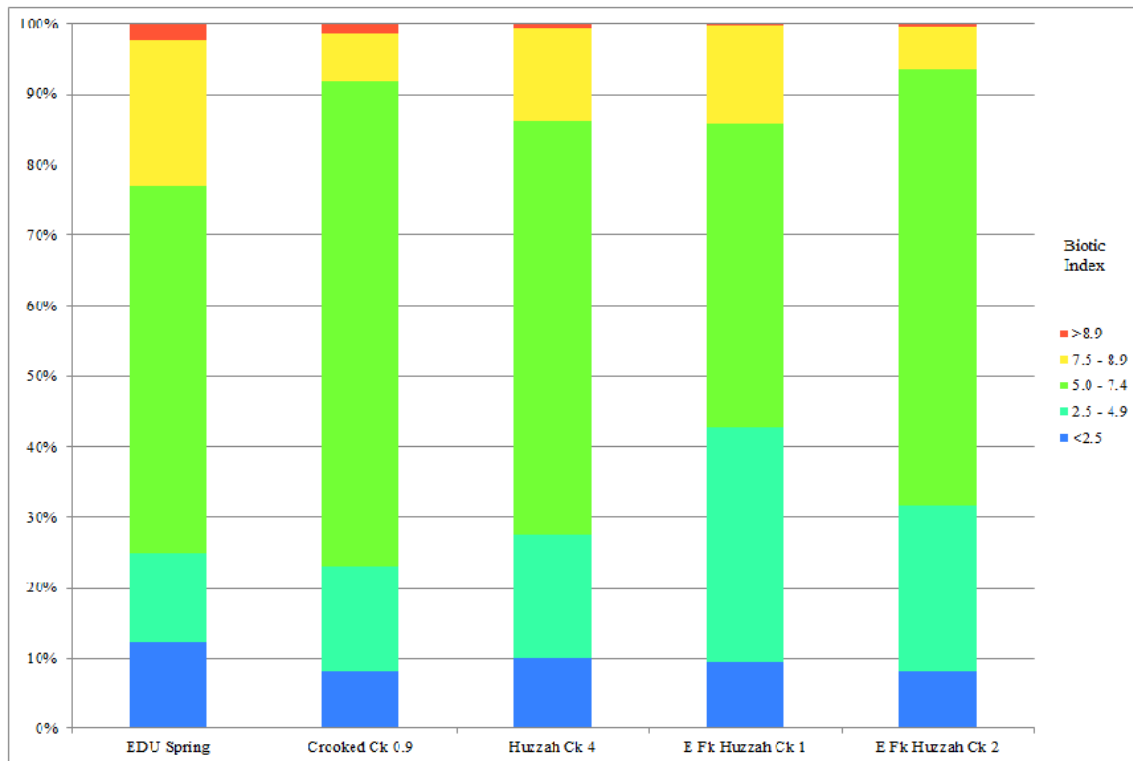


Figure 4. Spring 2017 Percent Taxa by Biotic Index Range

5.2.1 Additional Metrics to Analyze Metals Pollution

Percent Dominant Taxa

Percent of a single dominant taxon is expected to increase in response to mining related disturbances (Poulton et al. 2010). The percent dominance of a single taxon ranged from 11.2 percent to 29.8 percent in fall (Figure 5). The dominant taxa metric consisted of two taxa. *Cheumatopsyche* was dominant at Crooked Creek (11.7 percent of the macroinvertebrate community) and at East Fork Huzzah Creek 2 (11.2 percent). *Stenelmis* was the dominant taxon at Huzzah Creek 4 (29.8 percent and 29.4 percent, duplicate samples respectively) and East Fork Huzzah Creek 1 (20.1 percent).

During the spring, dominant taxa ranged from 15.6 percent to 43.4 percent and consisted of one taxon, the chironomid *Cricotopus/Orthocladius* grp. *Cricotopus/Orthocladius* grp. made up 15.6 percent of the macroinvertebrate community at East Fork Huzzah Creek 1, 16.9 percent at Huzzah Creek, 24.8 percent at East Fork Huzzah Creek 2, and 43.4 percent at Crooked Creek (Figure 5).

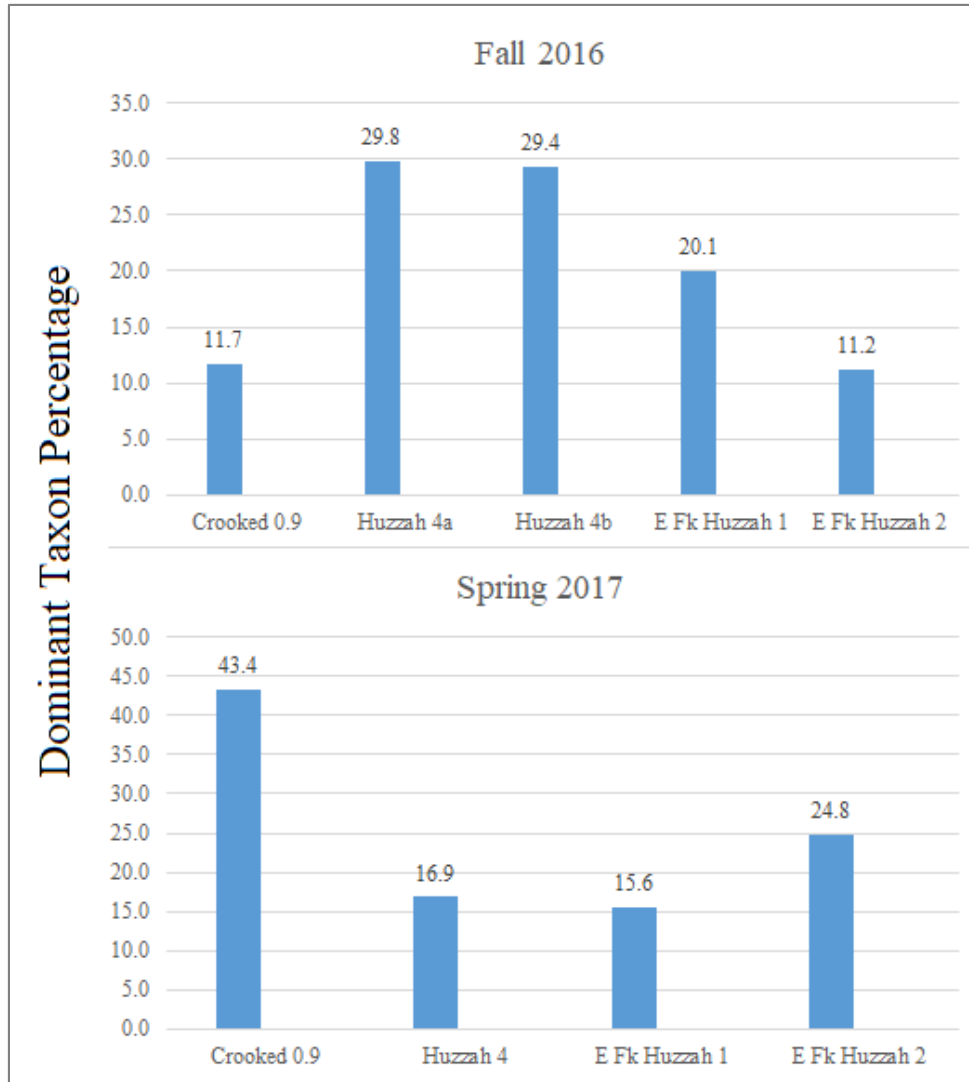


Figure 5. Dominant Taxon Percentage

Ratio of tolerant to intolerant Ephemeroptera

The ratio of tolerant to intolerant mayflies is expected to increase in response to mining related disturbances (Poulton et al. 2010). The ratio of tolerant to intolerant Ephemeroptera was highest at Huzzah Creek 4 and lowest at East Fork Huzzah Creek 2 during the fall. During the spring, the ratio was highest at Crooked Creek and lowest at East Fork Huzzah Creek 1 (Figure 6).

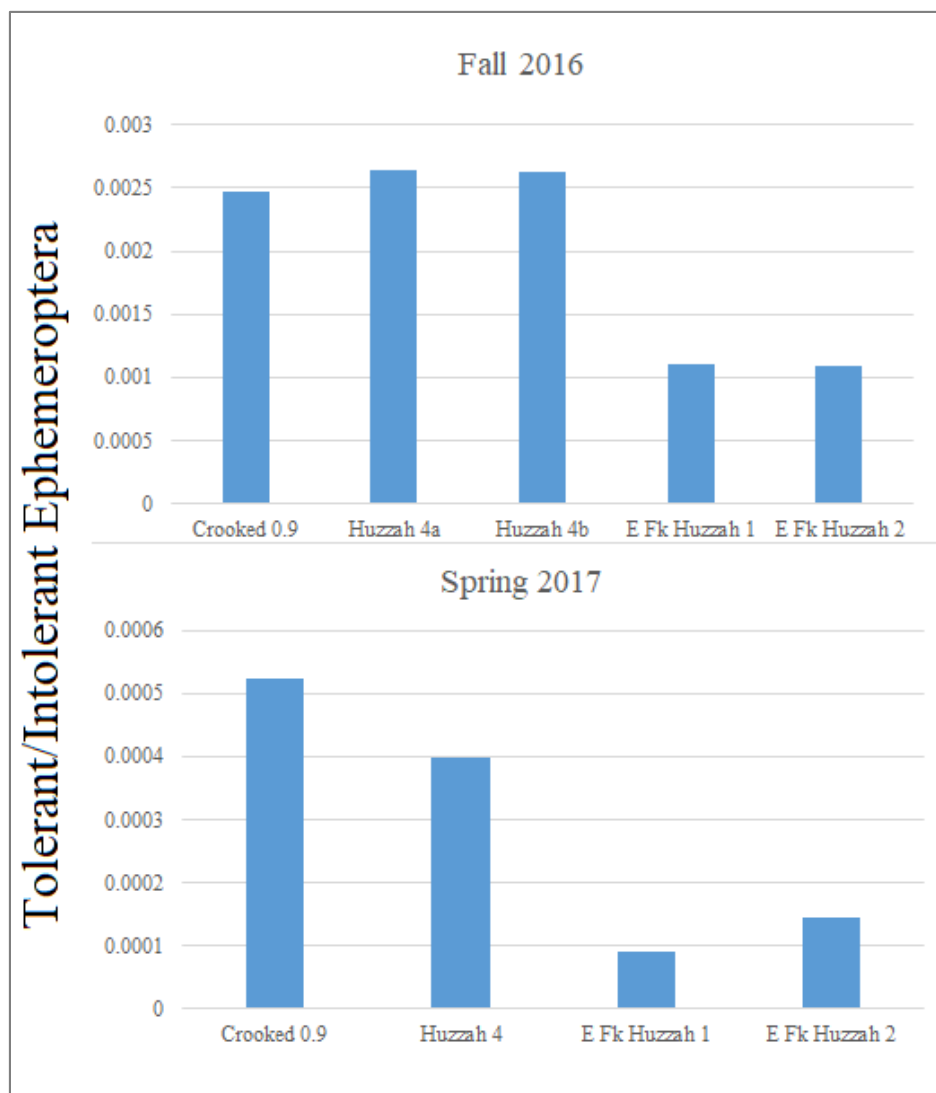


Figure 6. Tolerant/Intolerant Ephemeroptera

Percent scrapers

The percent of the functional feeding group scrapers tends to decrease in response to mining activities (Poulton et al. 2010). Percent scrapers ranged from 28.3 percent in Crooked Creek to 43.9 percent in Huzzah Creek 4b during the fall (Table 7). During the spring, percent scrapers were again lowest at Crooked Creek and highest at Huzzah Creek 4 (values ranged from 9.9 to 18.3) (Table 8).

Table 7. Fall 2016 Macroinvertebrate Functional Feeding Group Percentages.

Stations	BIOREF	Crooked	Huzzah	Huzzah	E Fk Huzzah	E Fk Huzzah
Variables	Average	Cr 0.9	Cr 4a	Cr 4b	Cr 1	Cr 2
Filterer/Collector	10.5	23.3	17.9	17.5	6.3	20.5
Gatherer/Collector	45.3	29.9	26.1	24.0	42.9	27.9
Piercers	0.3	0.1	0.1	0.1	0.0	0.0
Predators	9.3	9.3	10.2	7.4	6.7	11.0
Scrapers	20.9	28.3	39.3	43.9	40.7	34.3
Shredders	3.7	8.9	6.3	7.1	3.4	6.4

Table 8. Spring 2017 Macroinvertebrate Functional Feeding Group Percentages.

Stations	BIOREF	Crooked	Huzzah	E Fk Huzzah	E Fk Huzzah
Variables	Average	Cr 0.9	Cr 4	Cr 1	Cr 2
Filterer/Collector	10.1	8.4	23.8	14.3	16.0
Gatherer/Collector	43.9	14.8	20.0	37.8	22.8
Piercers	1.5	0.3	0.1	0.3	0.1
Predators	12.3	13.3	13.5	10.5	15.0
Scrapers	18.9	9.9	18.3	16.9	12.1
Shredders	13.3	53.3	24.4	20.1	34.5

Percent Chironomidae

The percentage of Chironomidae is expected to increase with mining related activities (Poulton et al. 2010). Chironomidae percentages per station for each season are shown in Tables 5 and 6, Section 5.2. During the fall, percent Chironomidae was highest at Huzzah Creek 4 (25.1 percent) and lowest at East Fork Huzzah Creek 1 (9.8 percent). During the spring, Chironomidae ranged from 66.5 percent at East Fork Huzzah Creek 2 to 44.6 percent at East Fork Huzzah Creek 1.

5.2.2 Biological Assessment QSIT

During the fall sampling season, macroinvertebrate duplicate samples were collected at Huzzah Creek 4. These samples were analyzed for QSIT to determine whether they met the 70 percent threshold for duplicate samples (Rabeni et al. 1999, MoDNR 2012). The QSIT for these two samples was 83%.

5.3 Physicochemical Water Parameters

Discharge and *in situ* results are presented in Tables 9 and 10. Physicochemical values varied throughout the watershed for each season.

DO levels ranged from 7.72 mg/L to 9.30 mg/L during the fall sampling period. pH was within the WQS criteria range of 6-9 at Crooked Creek and the East Fork Huzzah Creek stations. An equipment malfunction prevented collection of pH at Huzzah Creek 4. Specific conductance was slightly lower at the East Fork Huzzah Creek stations.

Table 9. Fall 2016 Discharge and *In Situ* Water Quality Measurements

Stations	Crooked Cr 0.9	Huzzah Cr 4a	Huzzah Cr 4b	E Fk Huzzah 1	E Fk Huzzah 2
Sampling time and date	1410h 9/20	1044h 9/20	1047h 9/20	1640h 9/20	0835h 9/21
Dissolved Oxygen (mg/L)	7.72	8.42	8.47	9.30	8.29
pH (su)	7.66	*	*	8.21	7.90
Specific Conductance (µS/cm)	354	342	341	281	296
Temperature (°C)	22.1	21.0	21.0	23.2	19.3
Turbidity (NTU)	1.6	3.2	2.3	3.9	2.4
Discharge (cfs)	6.2	55.7	55.6	18.2	10.4

* Equipment malfunction; Bold = in exceedance of U.S. EPA recommended value (USEPA 2000).

During the spring sampling season, DO levels ranged from 8.13 mg/L to 12.19 mg/L. pH values were consistent through the study stations, and all stations were within the WQS criteria range of 6-9. Specific conductance was comparable among all stations. Turbidity and discharge values were lower during the spring sampling period compared to the fall.

Table 10. Spring 2017 Discharge and *In Situ* Water Quality Measurements

Stations	Crooked Cr 0.9	Huzzah Cr 4	E Fk Huzzah 1	E Fk Huzzah 2
Sampling time and date	1215h 3/14	1030h 3/14	1345h 3/14	1515h 3/14
Dissolved Oxygen (mg/L)	8.13	8.26	8.41	12.19
pH (su)	8.41	8.26	8.41	8.5
Specific Conductance (µS/cm)	368	371	367	340
Temperature (°C)	8.0	7.1	6.5	6.5
Turbidity (NTU)	<1	<1	<1	<1
Discharge (cfs)	4.3	41.7	12.2	6.6

Currently, there are no nutrient criteria for Missouri streams and rivers. Nutrient values are compared to U. S. EPA Ecoregion 39 suggested criteria for the Ozark Highlands (USEPA 2000). The U. S. EPA recommended values are: 0.289 mg/L total nitrogen; 0.007 mg/L total phosphorus; and 1.42 NTU turbidity. Water chemistry concentrations are presented in Tables 9 and 10.

During the fall sampling season (Table 11), total nitrogen and total phosphorus were below U. S. EPA's recommended values. Turbidity values (reported in Table 9) ranged from 1.6 NTU to 3.6 NTU and exceeded U. S. EPA's recommended value of 1.42 NTU. Ammonia as N, sulfate, and chloride were within acceptable concentration ranges based on the WQS (MoDNR 2014). However sulfate values were higher in Crooked Creek when compared to Huzzah Creek 4 or the East Fork Huzzah Creek stations.

Table 11. Fall 2016 Water Chemistry Concentrations

Stations	Crooked Cr 0.9	Huzzah Cr 4a	Huzzah Cr 4b	E Fk Huzzah 1	E Fk Huzzah 2
Sampling time and date	1410h 9/20	1044h 9/20	1047h 9/20	1640h 9/20	0835h 9/21
Nitrate+Nitrite as N (mg/L)	0.14	0.18	0.18	0.12	0.14
Total Nitrogen (mg/L)	0.17	0.26	0.28	0.17	0.18
Total Phosphorus (mg/L)	<0.01 ND	<0.01 ND	<0.01 ND	<0.01 ND	<0.01 ND
Ammonia as N (mg/L)	<0.03 ND	<0.03 ND	<0.03 ND	<0.03 ND	<0.03 ND
Sulfate (mg/L)	20.8	7.10	7.77	4.13	4.27
Chloride (mg/L)	2.08	2.80	2.62	2.95	2.39
Total Suspended Solids (mg/L)	<5 ND	<5 ND	<5 ND	<5 ND	<5 ND

ND = not detected at reported value

During the spring sampling season (Table 12), total nitrogen and turbidity (see Table 10 for turbidity values) were below U. S. EPA's recommended values. Total phosphorus was elevated at East Fork Huzzah Creek 1 (value of 0.10 mg/L), but it was below the U. S. EPA's recommended value of 0.007 mg/L at Crooked Creek, Huzzah Creek 4, and East Fork Huzzah Creek 2. As was the case with fall samples, ammonia as N, sulfate, and chloride were within acceptable concentrations based on the WQS (MoDNR 2014), and sulfate was again higher at Crooked Creek when compared with the other study stations.

Table 12. Spring 2017 Water Chemistry Concentrations

Stations	Crooked Cr 0.9	Huzzah Cr 4	E Fk Huzzah 1	E Fk Huzzah 2
Sampling time and date	1215h 3/14	1030h 3/14	1345h 3/14	1515h 3/14
Nitrate+Nitrite as N (mg/L)	0.11	0.12	0.14	0.083
Total Nitrogen (mg/L)	0.14	0.18	0.16	0.12
Total Phosphorus (mg/L)	<0.01 ND	<0.01 ND	0.010	<0.01 ND
Ammonia as N (mg/L)	<0.03 ND	<0.03 ND	<0.03 ND	<0.03 ND
Sulfate (mg/L)	15.5	6.55	5.46	4.89
Chloride (mg/L)	2.40	2.50	3.09	2.80
Total Suspended Solids (mg/L)	<5 ND	<5 ND	<5 ND	<5 ND

ND = not detected at reported value; Bold = in exceedance of U. S. recommended value (USEPA 2000).

Dissolved metals concentrations are presented in Tables 13 and 14. The dissolved cadmium chronic concentration standard (MoDNR 2014) was exceeded during both seasons at Crooked Creek. Calculations of the criteria with the applicable hardness value per season (hardness values are presented in Tables 11 and 13) resulted in a chronic dissolved cadmium standard of 0.36 µg/L during the fall and 0.40 µg/L during the spring. The remaining dissolved metals analyzed did not exceed the standards at Crooked Creek. There were no exceedances at Huzzah Creek 4 or either of the East Fork Huzzah Creek stations.

Table 13. Fall 2016 Dissolved Metals Concentrations

Stations	Crooked Cr 0.9	Huzzah Cr 4a	Huzzah Cr 4b	E Fk Huzzah 1	E Fk Huzzah 2
Sampling time and date	1410h 9/20	1044h 9/20	1047h 9/20	1640h 9/20	0835h 9/21
Barium-Dissolved (µg/L)	33.4	41.9	42.2	40.4	39.3
Cadmium-Dissolved (µg/L)	0.84	0.10*	<0.1 ND	<0.1 ND	<0.1 ND
Lead-Dissolved (µg/L)	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND
Nickel-Dissolved (µg/L)	1.72	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND
Zinc-Dissolved (µg/L)	2.37	1.61	1.16	1.16	4.85
Calcium-Dissolved (mg/L)	35.7	35.4	34.8	32.6	29.7
Magnesium-Dissolved (mg/L)	20.7	20.8	20.5	19.6	17.7
Hardness as CaCO ₃ (mg/L)	174	174	171	162	147

ND not detected at reported value; * Estimated value, Detected below Practical Quantitation Limits;
 Bold = in exceedance of WQS.

Table 14. Spring 2017 Dissolved Metals Concentrations

Stations	Crooked Cr 0.9	Huzzah Cr 4	E Fk Huzzah 1	E Fk Huzzah 2
Sampling time and date	1215h 3/14	1030h 3/14	1345h 3/14	1515h 3/14
Barium-Dissolved (µg/L)	23.7	31.1	31.2	28.4
Cadmium-Dissolved (µg/L)	0.54	0.13*	<0.1 ND	0.13*
Lead-Dissolved (µg/L)	<0.5 ND	<0.5 ND	<0.5 ND	<0.5 ND
Nickel-Dissolved (µg/L)	1.63	1.0	0.95*	0.95*
Zinc-Dissolved (µg/L)	1.93	0.71*	1.04	2.76
Calcium-Dissolved (mg/L)	40.9	41.9	38.0	37.8
Magnesium-Dissolved (mg/L)	24.9	25.9	23.4	23.6
Hardness as CaCO ₃ (mg/L)	205	211	191	192

ND not detected at reported value; * Estimated value, Detected below Practical Quantitation Limits;
 Bold = in exceedance of WQS.

5.4 Sediment Analysis for Metals

During the fall sampling season, sediment samples were collected using a 2 mm (#10) sized sieve at Crooked Creek and the East Fork Huzzah Creek sampling stations. Sediment was not sieved at Huzzah Creek 4. The department judges a stream to be impaired when the sediment of the stream exceeds the PEC values by more than 150 percent. At Crooked Creek, cadmium and lead were both determined to be in exceedance. Arsenic, copper, nickel, and zinc were not in exceedance. No parameters were in exceedance at either of the East Fork Huzzah Creek station (Table 15).

Table 15. Fall 2016 Sieved Benthic Sediment Metals Concentrations

Stations	Crooked Cr 0.9	E Fk Huzzah 1	E Fk Huzzah 2	PEC	150% PEC
Sampling time and date	1440 9/20	1720 9/20	0930 9/21	--	--
Arsenic µg/kg	12,700	3,190	5,550	33,000	49,500
Cadmium µg/kg	16,500	1,400	2,280	4,980	7,470
Copper µg/kg	38,200	10,300	9,860	149,000	223,500
Lead µg/kg	269,000	45,600	66,500	128,000	192,000
Nickel µg/kg	48,400	8,310	8,670	48,600	72,900
Zinc µg/kg	162,000	93,900	146,000	459,000	688,500

Bolded values are above the 150 percent PEC threshold and are considered harmful to aquatic biota.

5.5 Past MSCI Scores

Crooked Creek and East Fork Huzzah Creek 1 were sampled during the 2001-2002 bioassessment period. Both stations scored fully supporting during the fall and partially supporting during the spring. The metrics TR, EPT, and SDI were all suboptimal during the spring sampling.

Crooked Creek (two separate stations: the current station plus an additional station upstream) and East Fork Huzzah Creek 2 were sampled during the 2008-2009 bioassessment period. East Fork Huzzah Creek 2 scored fully supporting during the fall. Both Crooked Creek stations scored partially supporting during the fall. All stations scored partially supporting during the spring (Table 16).

Table 16. Past MSCI Scores

Sampling Season	Fall 2001	Spring 2002	Fall 2008	Spring 2009
Stations	Support Category (MSCI Scores)			
Crooked Creek 1	Full (16)	Partial (14)	Partial (12)	Partial (14)
Crooked Creek 2	--	--	Partial (12)	Partial (12)
E Fk Huzzah Creek 1	Full (18)	Partial (14)	--	--
E Fk Huzzah Creek 2	--	--	Full (20)	Partial (14)

6.0 Discussion

6.1 Stream Habitat

Crooked Creek differed the most from the control habitat assessment. Crooked Creek had higher embeddedness, lower flow status, lower riffle quality, and a riparian area that ranked lower when compared to the control habitat assessment. Due to the lower channel status, less habitat was available to the macroinvertebrate community. Both East Fork Huzzah Creek stations also had more embeddedness than the control assessment station, but these stations also had fewer parameters that deviated from the control assessment. Increased sediment deposition, suboptimal riffle quality, and suboptimal riparian zone width can have an effect on the macroinvertebrate community composition (Lemly 1982; Zweig and Rabeni 2001).

6.2 Biological Assessment and Macroinvertebrate Community Analysis

All stations had fully supporting MSCI scores during the fall sampling period, with scores ranging from 16 to 20. East Fork Huzzah Creek 2 was the only station to score optimally in all four metrics that compose the MSCI. BI was suboptimal at all remaining stations. However, the BI metric was developed for organic pollution, which may not correspond with metals pollution (Lenat 1993). During the spring, BI was optimal at all stations and TR was suboptimal at all stations. Huzzah Creek 4 and East Fork Huzzah Creek 1 both attained fully supporting MSCI scores, and Crooked Creek and East Fork Huzzah Creek 2 scored partially supporting in the spring. East Fork Crooked Creek 2 is the only station classified as a class “C” stream, but since this station scored fully supporting in the fall, it is difficult to render the classification as a factor in the scoring.

The additional metrics used by Poulton et al. (2010) to examine the response of macroinvertebrate communities to mining related disturbances showed consistencies per season but not across seasons. During the fall, Huzzah Creek 4 showed the most response to these metrics with the highest percent of a single dominant taxon, highest percent of Chironomidae, and highest ratio of tolerant/intolerant mayflies. However, Crooked Creek had the lowest percentage of scrapers during the fall sampling period (the ratio of tolerant/intolerant mayflies in Crooked Creek was similar to Huzzah Creek 4). During the spring, Crooked Creek had the highest percent of a single dominant taxon (*Cricotopus/Orthocladius* grp.), highest ratio of tolerant/intolerant mayflies, and lowest percentage of scrapers. East Fork Huzzah Creek 2 had the highest percentage of Chironomidae (Crooked Creek contained a slightly lower percentage). Crooked Creek has shown impairment in the past due to dissolved metals toxicity in the surface water and metals toxicity in the sediment.

In addition, Clements et al. (1992) found that the net spinning caddisflies Hydropsychidae and Orthocladiinae chironomids were dominant at sites affected by heavy metals. Hydropsychidae were present at all stations during both seasons (see Tables 5 and 6). At Crooked Creek and East Fork Huzzah Creek 2 during the fall, net spinning caddisflies were approximately 10 times higher in abundance than the average of the BIOREF data. During the spring, the caddisflies were five times as abundant at Huzzah Creek 4. These observations may correspond with Poulton’s additional metrics (Poulton et al. 2010) to indicate that metals effects are present at Crooked Creek. The Orthocladiinae *Cricotopus/Orthocladius* grp. was the most common taxa group collected at all stations during the spring sampling period. The percentage of *Cricotopus/Orthocladius* grp. at Crooked Creek was 43.4, four times higher than the BIOREF average of 10.7 percent.

Clements et al. (2000) found heptageniid mayflies to be sensitive of metal pollution, with Heptageniidae being reduced by 75 percent in streams affected by metals pollution. At least five taxa of Heptageniidae were collected from all stations during both seasons. Taxa included (but not all inclusive) *Leucrocuta*, *Maccaffertium bednariki*, *M. pulchellum*, *M. mediopunctatum*, *M. terminatum*, *Stenacron*, and *Stenonema femoratum*.

During the fall, the percentage of heptageniid mayflies in samples ranged from 4.2 percent to 8.9 percent. The lowest percentage of heptageniid mayflies in samples occurred at one of the duplicate samples from Huzzah Creek 4. In the corresponding duplicate sample, the percentage of heptageniid mayflies was 7.1 percent. The percentage of heptageniids at the remaining three stations ranged from 8.6 to 8.9. In the spring, the percentage of heptageniids ranged from 4.5 at Crooked Creek (the stations exhibiting the most effect from metals pollution) to 9.1 percent at Huzzah Creek 4. The East Fork Crooked Creek stations had 6.7 and 6.8 percent heptageniids in the samples.

6.3 Physicochemical Water Parameters and Dissolved Metals

Physicochemical water parameters and nutrient values were within acceptable ranges, with the exception of total phosphorus at East Fork Huzzah Creek 1 and dissolved cadmium at Crooked Creek. Although sulfate was not in exceedance of the acute or chronic standard, it was higher at the Crooked Creek station than the other study stations. Allert et al. (2008) found sulfate to be higher downstream of mining activities.

Cadmium exceeded the chronic criterion in the previous bioassessment of Crooked Creek (2008-2009), but it was lower than the acute criterion. Dissolved cadmium also exceeded the WQS chronic standard during both seasons in the current study but, as was the case with the 2008-2009 study, it was below the acute standard. Aquatic organisms are exposed to dissolved metals through absorption to or uptake across the gills. Dissolved metals are typically more toxic to aquatic organisms than particulate forms. Metals can affect aquatic organisms in water and in sediment (Rainbow 1996, Maret et al. 2003)

6.4 Sediment Analysis for Metals

Both cadmium and lead exceeded the 150 percent PEC threshold at Crooked Creek. Cadmium was more than two times higher than what is considered harmful to aquatic biota. Lead was 40 percent higher than what is considered harmful to aquatic biota. Channel flow status was lowest at Crooked Creek; lower flow may be concentrating metals through the loss of dilution (Gerhardt et al. 2004).

6.5 Past MSCI Scores

In the past, the East Fork Huzzah Creek stations have scored fully supporting the fall and partially supporting in the spring. Crooked Creek, however, only scored fully supporting during the fall of 2001; it attained partially supporting scores during the fall of 2002 and both spring seasons. In the 1960s, mining activity in Missouri shifted from the Old Lead Belt to an area known as the Viburnum Trend located in Crawford, Washington, Iron, Dent, Reynolds, and Shannon counties (Poulton et al. 2010). Crooked Creek has likely experienced the most direct effect from the mining activities of the Viburnum Trend.

7.0 Summary

Tests of the null hypotheses resulted in the following conclusions:

- 1) Stream habitat assessment scores of Crooked Creek, Huzzah Creek, and East Fork Huzzah Creek will be similar to those of Huzzah Creek, the BIOREF station located in the Ozark/Meramec EDU.

This hypothesis is accepted. The SHAPP scores of the study stations all scored >75% of the SHAPP control stream.

- 2) The macroinvertebrate communities in Crooked Creek, Huzzah Creek, and East Fork Huzzah Creek will be similar to the macroinvertebrate communities of BIOREF streams in the Ozark/Meramec EDU.

This hypothesis is rejected. All stations attained fully supporting status during the fall season. However, during the spring, both Crooked Creek 0.9 and East Fork Huzzah Creek 2 only scored in partial support of the protection of the aquatic life beneficial use designation.

- 3) Physicochemical water quality of Crooked Creek, Huzzah Creek and East Fork Huzzah Creek will meet the WQS.

This hypothesis is rejected for Crooked Creek. Dissolved cadmium, which has been noted as an issue in Crooked Creek, exceeded the chronic standard for both sampling seasons. This hypothesis is accepted for Huzzah Creek and both of the East Fork Huzzah Creek Stations.

- 4) Metals toxicity values of the sediment samples will be meet MacDonald's recommended PEC values times 150 percent.

This hypothesis is rejected for Crooked Creek. Both total cadmium and total lead values were in exceedance. This hypothesis is accepted for both of the East Fork Huzzah Creek stations.

8.0 Conclusion

Metals have been extensively mined in the last century in the Interior Highlands of the central United States, a portion including the Ozark Plateau in Missouri (Poulton et al. 2010). Over time, new technologies have been developed to better streamline and improve the mining process and treatment of wastes. Mines are operating with stricter environmental controls. Although effects appear within the aquatic macroinvertebrate communities, particularly within Crooked Creek, the communities overall appear to be trending toward a more healthy condition.

9.0 Literature Cited

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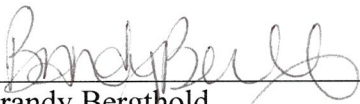
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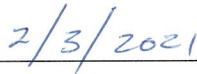
Biological Assessment Report
Crooked Creek, Huzzah Creek and East Fork Huzzah Creek
Crawford and Dent Counties Missouri, Fall 2016 – Spring 2017
Page 29 of 30

Submitted by:



Brandy Bergthold
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Water Quality Monitoring Section
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Date:



2/3/2021

Approved by:



Lynn Milberg
Water Quality Monitoring Section Chief
Environmental Services Program

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Appendix A

Invertebrate Database Bench Sheet Report Fall 2016 and Spring 2017:
Huzzah, East Fork Huzzah Creek, and Crooked Creeks, Dent and Crawford Counties
Grouped by Season and Station

Aquid Invertebrate Database Bench Sheet Report

Crooked Cr [16106], Station #0.9, Sample Date: 9/20/2016 2:05:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	4	5	
AMPHIPODA			
Hyalella azteca		2	14
BASOMMATOPHORA			
Ancylidae			1
Physella		1	8
COLEOPTERA			
Dubiraphia		3	7
Ectopria nervosa	1	1	1
Helichus basalis			1
Helichus lithophilus	1		2
Macronychus glabratus			2
Microcylloepus pusillus			1
Optioservus sandersoni	5	2	
Psephenus herricki	39	25	
Scirtidae			1
Stenelmis	33	69	3
DECAPODA			
Faxonius medius	1	-99	-99
Faxonius punctimanus			-99
DIPTERA			
Ablabesmyia		12	2
Antocha	1		
Chironomidae	1	3	2
Corynoneura		2	
Cricotopus bicinctus	2		
Cricotopus/Orthocladus	23	6	39
Cryptochironomus		1	
Forcipomyiinae		2	6
Hemerodromia	2		3
Hexatoma		4	
Labrundinia		1	1
Nilotanytus			1
Parakiefferiella		3	6
Parametriocnemus		1	
Polypedilum flavum	7		2
Polypedilum illinoense grp			2
Polypedilum scalaenum grp		1	
Polypedilum tritum			1
Pseudochironomus			1
Pseudosmittia			1
Rheocricotopus	1		1
Rheotanytarsus	23	1	10

Aquid Invertebrate Database Bench Sheet Report

Crooked Cr [16106], Station #0.9, Sample Date: 9/20/2016 2:05:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Simulium	16		1
Stempellinella	1	1	
Tabanus	-99	-99	
Tanytarsus	4	2	6
Thienemanniella	4	4	
Thienemannimyia grp.	2	10	14
Tipula		1	2
Tribelos		10	
Zavrelimyia			1
EPHEMEROPTERA			
Acentrella	21	1	
Baetis	79		15
Caenis anceps		2	
Caenis latipennis	1	45	69
Eurylophella			7
Isonychia bicolor	44		2
Leucrocuta	1		
Maccaffertium mediopunctatum	-99		
Maccaffertium pulchellum	28		1
Maccaffertium terminatum			2
Plauditus	15		2
Proclleon		4	
Stenacron		10	
Stenonema femoratum		63	1
Tricorythodes	5	4	5
LUMBRICINA			
Lumbricina	2	-99	
MEGALOPTERA			
Corydalus	1		
NEOTAENIOGLOSSA			
Elimia	17		23
Hydrobiidae	1		
ODONATA			
Argia		13	
Boyeria			-99
Hagenius brevistylus		3	
Hetaerina			9
Stylogomphus albistylus		2	-99
PLECOPTERA			
Leuctra	-99	-99	
Perlidae		2	
TRICHOPTERA			
Ceratopsyche morosa grp	31		
Cheumatopsyche	136	1	4
Chimarra	-99		1

Aquid Invertebrate Database Bench Sheet Report

Crooked Cr [16106], Station #0.9, Sample Date: 9/20/2016 2:05:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Helicopsyche		1	
Hydroptila	4		
Oecetis			19
Polycentropus		1	
Triaenodes			21
TRICLADIDA			
Planariidae	2	1	

Aquid Invertebrate Database Bench Sheet Report

Huzzah Cr [16104], Station #4a, Sample Date: 9/20/2016 10:55:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	17	2	1
AMPHIPODA			
Hyalella azteca			4
BASOMMATOPHORA			
Ancylidae			1
Menetus		1	
COLEOPTERA			
Dubiraphia		4	31
Ectopria nervosa	1	3	1
Laccobius		1	
Macronychus glabratus			1
Microcylloepus pusillus			3
Optioservus sandersoni	45	1	
Psephenus herricki	14	11	
Stenelmis	231	220	7
DECAPODA			
Faxonius luteus	-99	-99	-99
DIPTERA			
Atherix	-99		
Ceratopogoninae	1		
Chironomidae	1		1
Chrysops		1	
Cricotopus bicinctus			17
Cricotopus/Orthocladus	7	2	40
Cryptochironomus		1	
Dicrotendipes		1	1
Forcipomyiinae	1		
Hemerodromia	7		2
Labrundinia		5	27
Parakiefferiella		1	1
Parametrioctenemus	1		

Aquid Invertebrate Database Bench Sheet Report

Huzzah Cr [16104], Station #4a, Sample Date: 9/20/2016 10:55:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Phaenopsectra			1
Polypedilum flavum	11		3
Pseudochironomus			2
Rheocricotopus	2		
Rheotanytarsus	29	4	94
Simulium			5
Stempellinella	3	2	1
Tabanus	2	-99	
Tanytarsus	21	15	58
Thienemanniella		1	
Thienemannimyia grp.	6	6	12
Tipula	-99		
Tribelos		5	
Tvetenia vitracies			1
Zavrelimyia		1	1
EPHEMEROPTERA			
Acentrella	18		7
Acerpenna	6		
Baetis	44		36
Caenis anceps	35	18	1
Caenis latipennis	5	70	17
Choroterpes		-99	
Eurylophella	1	1	6
Isonychia bicolor	7		
Leptophlebiidae		1	
Leucrocuta	6	3	
Maccaffertium bednariki	15		
Maccaffertium mediopunctatum	6		
Plauditus	7	3	5
Procloeon		3	11
Serratella	2		
Stenacron		1	
Stenonema femoratum		29	4
Tricorythodes	12	6	13
LUMBRICINA			
Lumbricina	1	-99	
MEGALOPTERA			
Corydalus	1		
Nigronia serricornis		-99	
NEOTAENIOGLOSSA			
Elimia		-99	1
ODONATA			
Argia		2	
Basiaeschna janata			-99
Boyeria			-99

Aquid Invertebrate Database Bench Sheet Report

Huzzah Cr [16104], Station #4a, Sample Date: 9/20/2016 10:55:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Enallagma			1
Gomphidae	1	1	
Hagenius brevistylus		2	-99
Hetaerina			4
Macromia			-99
Stylogomphus albistylus		-99	
PLECOPTERA			
Agnetina flavescens	-99		
Neoperla	14		
Perlidae	14	1	
Perlinella ephyre	1		
Pteronarcys pictetii			-99
TRICHOPTERA			
Ceratopsyche morosa grp	2		
Cheumatopsyche	35		2
Chimarra	2	1	
Helicopsyche	1		
Lype diversa		1	
Marilia	4		
Oecetis		3	19
Polycentropus		1	
Triaenodes			13
TRICLADIDA			
Planariidae	1	2	1

Aquid Invertebrate Database Bench Sheet Report

Huzzah Cr [16105], Station #4b, Sample Date: 9/20/2016 10:55:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina		1	
AMPHIPODA			
Hyalella azteca			14
BASOMMATOPHORA			
Physella			2
COLEOPTERA			
Dubiraphia		3	27
Ectopria nervosa	2	3	1
Helichus lithophilus			4
Macronychus glabratus			2
Microcylloepus pusillus			5
Optioservus sandersoni	21	6	
Psephenus herricki	17	19	1
Stenelmis	278	97	

Aquid Invertebrate Database Bench Sheet Report

Huzzah Cr [16105], Station #4b, Sample Date: 9/20/2016 10:55:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
DECAPODA			
Faxonius luteus	-99	-99	
Faxonius medius			1
Faxonius punctimanus			-99
DIPTERA			
Ablabesmyia		2	5
Chironomidae	1	1	1
Chironomus		1	
Chrysops		1	
Cricotopus bicinctus	1		16
Cricotopus/Orthocladius	2		46
Dicrotendipes		1	3
Hemerodromia	1	1	1
Hexatoma	3		
Labrundinia		2	7
Microtendipes	2		
Parakiefferiella			2
Paratanytarsus			3
Phaenopsectra	4	4	1
Polypedilum flavum	11		2
Polypedilum illinoense grp		2	4
Polypedilum scalaenum grp		3	
Pseudochironomus			1
Rheotanytarsus	28		50
Simulium	1		3
Stempellinella	4	2	1
Tabanus	-99		
Tanytarsus	22	12	50
Thienemanniella	1		
Thienemannimyia grp.			21
EPHEMEROPTERA			
Acentrella		3	13
Anthopotamus		1	
Baetis	17		4
Caenis anceps	47	19	5
Caenis latipennis	4	42	25
Eurylophella		1	1
Heptageniidae	23	2	2
Isonychia bicolor	3		3
Leptophlebiidae		1	2
Leucrocuta	8		1
Maccaffertium bednariki	11		
Plauditus	7		
Procloeon		3	4
Stenacron	1	2	

Aquid Invertebrate Database Bench Sheet Report

Huzzah Cr [16105], Station #4b, Sample Date: 9/20/2016 10:55:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Stenonema femoratum		41	
Tricorythodes	7	5	18
ISOPODA			
Caecidotea (Blind & Unpigmented)		1	
LUMBRICINA			
Lumbricina	-99	2	
MEGALOPTERA			
Corydalus	-99		
NEOTAENIOGLOSSA			
Elimia	1		3
ODONATA			
Basiaeschna janata			-99
Calopteryx			1
Enallagma			4
Gomphidae		1	
Hagenius brevistylus		3	1
Hetaerina			5
Macromia		-99	
Stylogomphus albistylus		2	1
PLECOPTERA			
Leuctridae			1
Neoperla	8		
Perlesta	1		
Perlidae	15		
Perlinella ephyre		1	
TRICHOPTERA			
Ceratopsyche morosa grp	2		
Cheumatopsyche	42		
Chimarra	3		
Helicopsyche	3		2
Hydroptila			1
Marilia	1		
Nectopsyche			1
Oecetis			7
Triaenodes			1
TRICLADIDA			
Planariidae	1		
TUBIFICIDA			
Enchytraeidae	1		
VENEROIDA			
Pisidiidae			1

Aquid Invertebrate Database Bench Sheet Report

East Fk Huzzah Cr [16107], Station #1, Sample Date: 9/20/2016 4:40:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	11		
AMPHIPODA			
Hyalella azteca			260
BASOMMATOPHORA			
Physella			21
COLEOPTERA			
Ancyronyx variegatus			1
Dubiraphia		2	13
Dytiscus			1
Ectopria nervosa	2	4	2
Heterosternuta			1
Macronychus glabratus			4
Microcylloepus pusillus			2
Optioservus sandersoni	46	17	
Psephenus herricki	14	37	1
Stenelmis	143	144	3
DECAPODA			
Faxonius punctimanus			1
DIPTERA			
Ablabesmyia		6	4
Chrysops	1		
Cladotanytarsus			1
Corynoneura	1		
Cricotopus bicinctus		1	2
Cricotopus/Orthocladius	17	3	12
Dicrotendipes		1	1
Forcipomyiinae	1		2
Hemerodromia	1		
Labrundinia		1	8
Nilotanypus	2		1
Parakiefferiella		2	4
Parametriocnemus	1		
Paratanytarsus			7
Polypedilum aviceps	2		
Polypedilum flavum	4		
Polypedilum illinoense grp			2
Pseudochironomus		1	
Rheocricotopus	2		
Rheotanytarsus	9	1	4
Simulium	1		
Stempellinella	1	2	1
Sympotthastia	3	2	
Tabanus		-99	
Tanytarsus	6	3	2

Aquid Invertebrate Database Bench Sheet Report

East Fk Huzzah Cr [16107], Station #1, Sample Date: 9/20/2016 4:40:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Thienemanniella	2	1	1
Thienemannimyia grp.	5	5	8
Tipula	1		
EPHEMEROPTERA			
Acentrella	46		2
Acerpenna	12		1
Baetis	88	1	2
Caenis anceps	25	12	1
Caenis latipennis	3	10	19
Choroterpes	1	4	
Dipheter	2		
Ephemerella	14		
Eurylophella	2	5	
Isonychia bicolor	18		
Leptophlebiidae		3	3
Leucrocota	3	1	
Maccaffertium bednariki	26	3	
Maccaffertium mediopunctatum	1		
Maccaffertium pulchellum	22		
Procloeon			3
Stenacron	5	22	
Stenonema femoratum		40	2
Tricorythodes	13	17	1
HEMIPTERA			
Microvelia			2
Rheumatobates			1
LUMBRICINA			
Lumbricina	2	1	
MEGALOPTERA			
Corydalus	1	-99	
NEOTAENIOGLOSSA			
Elimia	1		8
Hydrobiidae	1		
ODONATA			
Argia		2	9
Basiaeschna janata			2
Boyeria			-99
Calopteryx		1	4
Enallagma			8
Gomphidae			1
Hagenius brevistylus		-99	
Hetaerina			2
PLECOPTERA			
Leuctridae			1
Neoperla	-99	1	

Aquid Invertebrate Database Bench Sheet Report

East Fk Huzzah Cr [16107], Station #1, Sample Date: 9/20/2016 4:40:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Perlidae	1		
TRICHOPTERA			
Agapetus	3		
Ceratopsyche morosa grp	1		
Cheumatopsyche	42		
Chimarra	4		
Helicopsyche	10	6	
Marilia		1	
Oecetis		1	6
Pycnopsyche			-99
Triaenodes			3
TRICLADIDA			
Planariidae	5		3

Aquid Invertebrate Database Bench Sheet Report

East Fk Huzzah Cr [16108], Station #2, Sample Date: 9/21/2016 8:35:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	7	3	
AMPHIPODA			
Hyaella azteca		2	21
Stygobromus		4	
BASOMMATOPHORA			
Ancylidae			5
Menetus			1
Physella		5	15
BRANCHIOBELLELLIDA			
Branchiobdellida	2		
COLEOPTERA			
Dubiraphia		4	17
Ectopria nervosa	1	2	1
Enochrus	1		
Microcylloepus pusillus	1		
Optioservus sandersoni	48	21	
Psephenus herricki	29	8	
Stenelmis	44	24	7
DECAPODA			
Faxonius medius	1	1	1
Faxonius punctimanus			-99
DIPTERA			
Ablabesmyia		36	2
Antocha	1		
Cardiocladius	3		1

Aquid Invertebrate Database Bench Sheet Report

East Fk Huzzah Cr [16108], Station #2, Sample Date: 9/21/2016 8:35:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Chironomidae		5	
Chironomus		1	
Cladotanytarsus		3	1
Corynoneura		1	
Cricotopus bicinctus		2	1
Cricotopus/Orthocladius	15	8	6
Dicrotendipes		5	
Forcipomyiinae		2	
Hemerodromia	13		1
Hexatoma		5	
Labrundinia		2	2
Microtendipes		1	
Parakiefferiella		1	
Parametriocnemus	4		
Phaenopsectra		8	2
Polypedilum aviceps	2		2
Polypedilum flavum	18		1
Polypedilum illinoense grp		2	1
Rheocricotopus			1
Rheotanytarsus	9	1	10
Simulium	2		1
Stempellinella	1	3	1
Tabanus	5		
Tanytarsus	7	9	5
Thienemanniella	2	1	
Thienemannimyia grp.	1	3	6
Tipula	2		
Zavrelimyia		1	1
EPHEMEROPTERA			
Acentrella	7		1
Baetis	62		4
Caenis anceps	52	9	
Caenis latipennis		10	29
Eurylophella	3	1	12
Isonychia bicolor	55		2
Maccaffertium bednariki	4		
Maccaffertium mediopunctatum	1		
Maccaffertium pulchellum	55	10	
Paraleptophlebia		14	2
Procloeon		1	
Stenacron	1	9	
Stenonema femoratum		26	
Tricorythodes	6	4	2
HEMIPTERA			
Microvelia			2

Aquid Invertebrate Database Bench Sheet Report

East Fk Huzzah Cr [16108], Station #2, Sample Date: 9/21/2016 8:35:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Ranatra			-99
LUMBRICINA			
Lumbricina	-99	6	
MEGALOPTERA			
Corydalus	-99		
Nigronia serricornis	1		-99
NEOTAENIOGLOSSA			
Elimia	3	6	66
ODONATA			
Argia	1	1	-99
Basiaeschna janata			1
Boyeria			-99
Calopteryx		3	11
Enallagma			6
Gomphidae	2		
Hagenius brevistylus		1	1
PLECOPTERA			
Capniidae		1	
Leuctra	1		
Perlinella ephyre		1	
Pteronarcys pictetii			-99
TRICHOPTERA			
Ceratopsyche morosa grp	6		
Cheumatopsyche	128		5
Chimarra	2		
Helicopsyche	2	3	
Oecetis			3
Polycentropus		4	
Triaenodes			14
TRICLADIDA			
Planariidae	16		1
TUBIFICIDA			
Tubificidae		1	

Aquid Invertebrate Database Bench Sheet Report

Crooked Cr [17062], Station #0.9, Sample Date: 3/14/2017 12:15:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	34	9	1
AMPHIPODA			
Crangonyx		2	
Hyalella azteca			2

Aquid Invertebrate Database Bench Sheet Report

Crooked Cr [17062], Station #0.9, Sample Date: 3/14/2017 12:15:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
BASOMMATOPHORA			
Physella	2	1	16
COLEOPTERA			
Dubiraphia		2	2
Helichus basalis			1
Macronychus glabratus			1
Optioservus sandersoni	25	4	1
Psephenus herricki	6	1	
Stenelmis	2	2	
DECAPODA			
Faxonius luteus	-99		
DIPTERA			
Ablabesmyia		18	
Antocha	3		1
Ceratopogoninae		2	
Chironomidae	1		
Clinocera	5	9	
Corynoneura	2	3	2
Cricotopus bicinctus	3		1
Cricotopus trifascia	1		
Cricotopus/Orthocladius	316	103	183
Cryptochironomus		2	
Dicrotendipes		18	2
Eukiefferiella	8		1
Hemerodromia	16	1	
Labrundinia		1	2
Microtendipes	1	4	
Parakiefferiella		2	2
Parametrioctenemus	11		
Paratanytarsus		1	
Phaenopsectra	3	4	1
Polypedilum fallax grp		1	
Polypedilum flavum	2		
Potthastia	2	5	
Prosimulium	1		
Rheocricotopus	45		1
Rheotanytarsus	8		4
Simulium	3		
Stempellinella	6	3	
Sympotthastia	8		1
Synorthocladius	4	3	1
Tabanus	-99		
Tanytarsus	7	1	3
Thienemanniella	2		
Thienemannimyia grp.	21	23	19

Aquid Invertebrate Database Bench Sheet Report

Crooked Cr [17062], Station #0.9, Sample Date: 3/14/2017 12:15:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Tipula	1	-99	
Tvetenia bavarica grp	1		
Zavreliomyia (Paramerina)			1
EPHEMEROPTERA			
Acentrella	14		
Acerpenna	12	1	1
Caenis latipennis	2	11	7
Centroptilum		1	
Ephemerella invaria	-99		
Eurylophella bicolor	1		
Isonychia bicolor	20		
Maccaffertium bednariki	7		
Maccaffertium pulchellum	16		1
Maccaffertium terminatum	4		1
Stenacron		2	
Stenonema femoratum	-99	30	1
LUMBRICINA			
Lumbricina	-99	-99	
MEGALOPTERA			
Corydalus	-99		
NEOTAENIOGLOSSA			
Elimia	3		
ODONATA			
Argia		3	
Calopteryx			2
Hagenius brevistylus		1	
Hetaerina			1
Stylogomphus albistylus		1	
PLECOPTERA			
Acroneuria	1		
Amphinemura	33		
Isoperla	-99		
Leuctridae	24	55	4
Prostoia	1	1	
Pteronarcys pictetii	1		1
TRICHOPTERA			
Ceratopsyche morosa grp	16		
Cheumatopsyche	47		
Chimarra	1		
Helicopsyche	3		1
Hydroptila	4		
Oecetis			7
Polycentropus	1	2	1
Pycnopsyche	1		-99
Rhyacophila	1		

Aquid Invertebrate Database Bench Sheet Report

Crooked Cr [17062], Station #0.9, Sample Date: 3/14/2017 12:15:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Trienodes			8
TRICLADIDA			
Planariidae	5	2	

Aquid Invertebrate Database Bench Sheet Report

Huzzah Cr [17061], Station #4, Sample Date: 3/14/2017 10:30:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	21	5	1
AMPHIPODA			
Hyalella azteca			3
COLEOPTERA			
Dubiraphia		1	5
Optioservus sandersoni	23	5	
Psephenus herricki	6		
Stenelmis	37	13	
DECAPODA			
Faxonius medius		-99	
Faxonius punctimanus			-99
DIPTERA			
Ablabesmyia		16	
Antocha	1		
Atherix	-99		
Cardiocladius	16		2
Ceratopogoninae	1		
Chironomidae	0	1	1
Cladotanytarsus		2	
Clinocera	2		
Corynoneura		33	1
Cricotopus bicinctus	16	2	56
Cricotopus/Orthocladius	85	43	99
Cryptochironomus		4	
Dicrotendipes		22	12
Eukiefferiella	13		3
Hemerodromia	5	1	1
Hexatoma	6		
Labrundinia		3	2
Microtendipes	8	6	1
Nanocladius	1	1	
Parakiefferiella		10	1
Parametriocnemus	9	1	
Paratanytarsus		2	2
Phaenopsectra	1	8	

Aquid Invertebrate Database Bench Sheet Report

Huzzah Cr [17061], Station #4, Sample Date: 3/14/2017 10:30:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Polypedilum flavum	1		
Polypedilum illinoense grp		1	2
Potthastia		6	1
Prosimulium	1		
Rheocricotopus	1		
Rheotanytarsus	48	1	31
Simulium	4		5
Stempellinella	13	5	
Synorthocladus	9	4	1
Tabanus	1		
Tanytarsus	25	26	13
Thienemanniella			1
Thienemannimyia grp.	10	22	6
Zavrelinmyia		1	
EPHEMEROPTERA			
Acentrella	2		
Acerpenna	12	2	
Caenis anceps		3	
Caenis latipennis		21	3
Ephemerella invaria	18		
Eurylophella bicolor	10	11	3
Eurylophella enoensis			1
Isonychia bicolor	15		
Leptophlebiidae		3	
Leucrocuta	4	11	
Maccaffertium bednariki	39	3	
Maccaffertium mediopunctatum	25		
Maccaffertium pulchellum	1		
Maccaffertium terminatum	9		3
Stenacron		4	
Stenonema femoratum	1	23	
Teloganopsis deficiens	2		
LUMBRICINA			
Lumbricina	1		
MEGALOPTERA			
Corydalus	1		
NEOTAENIOGLOSSA			
Elimia		-99	13
ODONATA			
Argia		2	
Gomphidae	1		
Hagenius brevistylus		1	1
Hetaerina			1
Stylogomphus albistylus	1		
PLECOPTERA			

Aquid Invertebrate Database Bench Sheet Report

Huzzah Cr [17061], Station #4, Sample Date: 3/14/2017 10:30:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Agnetina flavescens	12		
Amphinemura	10		3
Isoperla	5		
Leuctridae		3	
Neoperla	13	3	
Perlesta	2		2
Perlinella drymo		1	
Perlinella ephyre		1	
Prostoia	6		2
TRICHOPTERA			
Ceratopsyche morosa grp	28		
Cheumatopsyche	107		
Helicopsyche	2	2	12
Hydroptila	1		
Mystacides		1	
Neophylax		1	
Oecetis			7
Polycentropus		2	
Psychomyia	2		
TRICLADIDA			
Planariidae	5		
TUBIFICIDA			
Limnodrilus hoffmeisteri		1	
Tubificidae		2	
VENEROIDA			
Pisidiidae		1	

Aquid Invertebrate Database Bench Sheet Report

East Fk Huzzah Cr [17063], Station #1, Sample Date: 3/14/2017 1:40:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	24	1	
AMPHIPODA			
Hyalella azteca			19
BASOMMATOPHORA			
Physella			1
COLEOPTERA			
Dubiraphia			3
Ectopria nervosa			1
Optioservus sandersoni	50	17	
Psephenus herricki		4	
Scirtidae			1
Stenelmis	7	2	1

Aquid Invertebrate Database Bench Sheet Report

East Fk Huzzah Cr [17063], Station #1, Sample Date: 3/14/2017 1:40:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
DECAPODA			
Faxonius medius			-99
Faxonius virilis			-99
DIPTERA			
Ablabesmyia		4	2
Antocha	2		1
Atherix	-99	-99	
Cardiocladius	3		
Chaetocladius		1	
Corynoneura	1	4	4
Cricotopus/Orthocladius	28	64	109
Dicrotendipes	4	48	44
Dixa			1
Eukiefferiella	2		
Hemerodromia	14	2	
Labrundinia		2	21
Micropsectra	3	15	2
Microtendipes	3	3	
Parakiefferiella		11	6
Parametriocnemus	3	1	
Paraphaenocladius			1
Paratanytarsus	1		33
Phaenopsectra		5	
Polypedilum aviceps	7		
Polypedilum flavum	2		1
Potthastia		3	1
Prosimulium	1		
Rheocricotopus	5		
Rheotanytarsus	2	2	3
Simulium	12		
Stempellinella	1	5	
Sympotthastia	1	3	2
Synorthocladius		1	2
Tabanus	-99	1	
Tanytarsus	1	31	22
Thienemanniella			1
Thienemannimyia grp.	14	20	9
Tipula	-99	-99	
Tvetenia bavarica grp	2		
Zavreliomyia			1
Zavreliomyia (Paramerina)			5
EPHEMEROPTERA			
Acentrella	99		1
Acerpenna	38		
Caenis latipennis		1	1

Aquid Invertebrate Database Bench Sheet Report

East Fk Huzzah Cr [17063], Station #1, Sample Date: 3/14/2017 1:40:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Ephemerella invaria	17		
Eurylophella bicolor		8	
Eurylophella enoensis			7
Heptageniidae			1
Isonychia bicolor	15		
Leptophlebia			2
Leucrocuta	4	4	
Maccaffertium bednariki	24	2	
Maccaffertium mediopunctatum	4	1	
Maccaffertium pulchellum	29	1	
Paraleptophlebia		3	
Siphonurus			5
Stenacron	1	6	
Stenonema femoratum		8	1
Teloganopsis deficiens	49		
LUMBRICINA			
Lumbricina	-99		
MEGALOPTERA			
Corydalus	1		
NEOTAENIOGLOSSA			
Elimia	1	-99	15
ODONATA			
Argia		2	1
Basiaeschna janata			-99
Calopteryx			-99
Gomphidae		1	
PLECOPTERA			
Acroneuria		-99	
Agneta flavescens	-99		
Amphinemura	26		
Isoperla	4		
Leuctridae	3	17	
Perlesta	1		
Perlidae	2		
Pteronarcys pictetii	-99		
TRICHOPTERA			
Agapetus	2		
Ceratopsyche morosa grp	15		
Cheumatopsyche	70	4	
Helicopsyche	2	3	20
Hydroptila	1	1	2
Lepidostoma	1		
Polycentropus		1	
Psychomyia	5		

Aquid Invertebrate Database Bench Sheet Report

East Fk Huzzah Cr [17063], Station #1, Sample Date: 3/14/2017 1:40:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Pycnopsycha			1
TRICLADIDA			
Planariidae	16		

Aquid Invertebrate Database Bench Sheet Report

East Fk Huzzah Cr [17064], Station #2, Sample Date: 3/14/2017 3:05:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	14	3	1
BASOMMATOPHORA			
Physella			-99
COLEOPTERA			
Dubiraphia		1	
Optioservus sandersoni	34	13	
Psephenus herricki	2	1	
Stenelmis		2	
DECAPODA			
Faxonius luteus			-99
Faxonius medius	-99		
Faxonius punctimanus		1	
DIPTERA			
Ablabesmyia		12	1
Antocha	8		
Cardiocladius	20	2	2
Ceratopogoninae	1		
Chelifera	1		1
Chironomidae	2	2	
Chrysops		-99	
Cladotanytarsus		3	
Clinocera	2		
Corynoneura	1	2	9
Cricotopus bicinctus			8
Cricotopus trifascia	8		1
Cricotopus/Orthocladius	86	49	170
Cryptochironomus		1	
Dicrotendipes	2	33	8
Eukiefferiella	9		1
Hemerodromia	22	2	
Labrundinia		2	7
Larsia			1
Micropsectra	10	9	3
Microtendipes		14	
Nilotanytus	2		

Aquid Invertebrate Database Bench Sheet Report

East Fk Huzzah Cr [17064], Station #2, Sample Date: 3/14/2017 3:05:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Parakiefferiella		21	2
Parametriocnemus	5		1
Paratanytarsus		4	3
Phaenopsectra		11	1
Polypedilum aviceps	35		3
Polypedilum flavum	5		
Polypedilum illinoense grp			3
Potthastia			1
Prosimulium	3		
Rheocricotopus	10		2
Rheotanytarsus	16		20
Simulium			6
Stempellinella	4	15	1
Sympotthastia		1	1
Synorthocladius	1		
Tabanus	-99		
Tanytarsus	4	67	13
Thienemanniella	3		4
Thienemannimyia grp.	48	17	7
Tvetenia bavarica grp	3		
Zavreliomyia (Paramerina)			5
EPHEMEROPTERA			
Acentrella	47		2
Acerpenna	9		1
Baetis			1
Caenis latipennis		6	
Ephemerella invaria	8		
Eurylophella bicolor	4	6	2
Eurylophella enoensis			3
Isonychia bicolor	18		
Leptophlebia			1
Maccaffertium bednariki	20	2	
Maccaffertium mediopunctatum	4		
Maccaffertium pulchellum	51		1
Stenacron	1	3	
Stenonema femoratum		2	
GORDIOIDEA			
Chordodidae	-99		
LUMBRICINA			
Lumbricina	-99	1	
MEGALOPTERA			
Corydalus	1		
NEOTAENIOGLOSSA			
Elimia	1		-99
ODONATA			

Aquid Invertebrate Database Bench Sheet Report

East Fk Huzzah Cr [17064], Station #2, Sample Date: 3/14/2017 3:05:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Basiaeschna janata			-99
Boyeria			-99
Gomphidae		1	
Stylogomphus albistylus		-99	
PLECOPTERA			
Amphinemura	11		
Isoperla	-99		
Leuctridae	37	7	
Perlidae	1		
TRICHOPTERA			
Ceratopsyche morosa grp	9		
Cheumatopsyche	26		
Hydroptila	1		
Pycnopsyche		-99	1
Rhyacophila	1		
TRICLADIDA			
Planariidae	3		